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ABSTRACT

This paper suggests an approach and an analysis of the impact that federal manpower programs have had on dentistry. The main beneficiaries under health manpower subsidy programs are indicated and some policy alternatives suggested. Emphasis is placed on federal subsidies for increasing the supply of dentists including students' financial assistance programs and construction and institutional support programs. The use of health manpower population ratios as a basis for public policy is also discussed. (MJM)

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Health Manpower Policy Discussion Paper Series

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I. Background.

Federal assistance for health manpower training began on a large scale in 1963 with The Health Professions Educational Assistance Act (Public Law 88-129 (H.R. 12)). This act was amended in 1965; it was renewed in 1968 (The Health Manpower Act of 1968, Public Law 90-490 (S. 3095)) and again in 1971 (Comprehensive Health Manpower Training Act of 1971, Public Law 92-157 (H.R. 8629)). This act is again up for renewal in 1974.

The direct recipients of such federal assistance have been both schools and students in the health professions of medicine, dentistry, osteopathy, podiatry, pharmacy, optometry, veterinary medicine and public health. The conditions under which federal funds were awarded have changed under successive amendments and renewals of the act. Perhaps the major effect of such changes has been to relate federal subsidies to enrollment increases.

Federal health manpower funds, which started on a large scale in 1965 and have been increasing each year, totaled 1.2 billion dollars for the period 1965-1971. Since legislation to continue federal assistance to the health professions is to be renewed in the coming year, an evaluation should be undertaken of such federal programs to determine:

(1) Should federal support to schools and students in the health professions be continued? The rationale for such subsidies should be made explicit.

(2) If it is to be continued, under what conditions should such federal monies be awarded, and

(3) How many federal dollars should be spent on the health professions?

The above questions should be asked, and answered, for each of the many health professions seeking to have their federal support renewed.

Given the sizeable federal financial assistance that has gone into this area and the probable magnitude of future federal subsidies if this legislation were to be renewed, it is essential to re-examine the federal role regarding subsidies to the health professions.

As a beginning step in this direction, an examination was made of the federal manpower programs as they have applied to dentistry. The question of whether dental manpower should be subsidized is not discussed, although it has been treated elsewhere.[1] This paper suggests an approach and an analysis of the impact that these federal manpower programs have had on dentistry. The main beneficiaries under health manpower subsidy programs are indicated and some policy alternatives suggested.

II. Federal Manpower Programs to Increase the Supply of Dentists.

As a result of predictions of impending shortages of dentists, a federal program for subsidizing dental schools and students was started. In 1962, representatives of the dental profession projected a "shortage" of 12,000 dentists by 1975. The estimate of the number of dentists required in 1975 was based on maintaining the dentist to population ratio that existed in 1958. To alleviate this shortage, it was proposed that existing dental schools increase their capacity in order to graduate 750 more dentists per year by 1975 and additional dental school capacity (22 new schools) be constructed so that an additional 2,200 graduates a year would be available by 1975. Such increments to existing dental schools and the creation of additional capacity would increase the number of dental graduates from 3,200 per year in 1962 to 6,200 per year in 1975 and forestall any shortage of dentists.[2]

The federal funds that were requested to implement such a program ($350 million) were provided. In retrospect, two questions might have been asked of such a program: First, given the assumption that the supply of dental care should have been equally available in 1975 as it was in 1958, could the funds have been spent in another way so as to achieve that goal at a lesser cost? Secondly, how proper was the maintenance of a dentist-population ratio as a basis for public policy? The rest of the paper will be concerned with these two questions.

A. Federal Subsidies for Increasing the Supply of Dentists:

Of the 310 million dollars awarded to dental schools and students during 1965-1971, the majority of these funds (262 million dollars) was spent on construction programs and for institutional support to the dental schools. Federal assistance to students (48 million dollars) was provided to the schools to be distributed for student loans and scholarships.

1. Student Financial Assistance Program: With regard to providing financial assistance to students, one might question how effective this program was in increasing the number of dentists? Alternatively, another goal of this program might have been a change in the mix of dental students, in which case we would want to determine whether such a change occurred as a result of this program.

Scholarships or low-cost loans would increase the rate of return to a dental education, hence, we would expect to observe an increase in demand for a dental education. In 1965 and 1970 the rate of return, without scholarship assistance, was approximately 25 percent.[3] Further, there were approximately

2.5 applicants to dental schools for each student enrolled during this period.[4] It appears, therefore, that the major constraint to increasing the number of dentists is not a low rate of return, but rather a limited supply of dental school spaces. Subsidizing students under these circumstances will merely serve to increase the already high rate of return of those becoming dentists. It will also provide the schools with a greater selection of applicants from which to choose.

If the student financial assistance program were to change the mix of dental students by increasing the proportion of students from families with lower incomes, then no data were requested to indicate whether such a change occurred. In 1963, 22 percent of dental students came from families with incomes greater than $15,000. This may be compared to the rest of the population in which only 5.4 percent of families had incomes greater than $15,000. Although no data were collected on family incomes of dental students for later years, some data are available on family incomes of medical students for the period 1963 and 1967. Medical schools had the same loan and scholarship program as dental schools. However, the distribution of medical student family incomes as compared to the distribution of family incomes for the entire U.S. population did not change from 1963 to 1967.[5] Hopefully, data in the future will be collected on family incomes of dental students to determine whether a change in student mix has occurred as a result of the scholarship and loan program.

2. Construction and Institutional Support Programs to Dental Schools: Since the constraint on additional student enrollments is the number of

dental school spaces, an examination of federal construction and institutional support to dental schools is likely to determine how effective the federal subsidy program was in increasing the supply of dental care.

Over the seven year period, 1965-1971, 1,123 new first-year places were created; 396 were a result of constructing six new dental schools and 727 spaces were created by expanding twenty-nine existing schools. Planned expenditures for such institutional support are expected to increase in amount from 1971-1975.[6] Some of the above new spaces would have been created without the federal subsidy program. In 1962 it was said that dental schools planned to increase the number of their spaces by 354. However, with federal assistance they would be able to create a total of 725 new places.[7]

To evaluate the effect of federal subsidies for increasing the number of dentists, it is necessary to look beyond just the number of additional dentists produced. One must be able to evaluate the effect that the program has had on the dental sector itself. When examined at the level of the demand and supply of dental care, it becomes possible to suggest alternative policies that would have similar effects. These alternative subsidy programs can then be contrasted on the basis of their relative costs as well as on their impact on the dental sector.

The approach used to evaluate the effect on the market for dental care of an increase in the number of dentists was to develop an econometric model of the dental sector. Although a more comprehensive empirical model of the dental sector would have been preferred, unavailability of data necessitated a number of compromises between our actual and conceptual model. The resulting model and applications are thus more illustrative of the type of

analyses that should be used for evaluating health manpower programs.

A description of the model and its equations is provided as an Appendix to this paper. Basically, the model has two levels; the dental education sector and the dental care market. In the educational sector, federal funds are used to create new spaces, hence, increased enrollment in dental schools. The resulting number of graduates, together with the stock of dentists, then become inputs into the production of dental services. The supply of dental services, together with demand for dental services, determine dental prices, the quantity of dental visits, total expenditures on dental care and consequently dental incomes.

Thus, to analyze the impact of federal subsidies for increasing the number of dentists, the econometric model was used to simulate these consequences on the dental market. Another simulation was then conducted which assumed that the number of dental graduates would increase at the same rate as prior to the start of such federal subsidies. The outcomes of these simulations are shown in Tables 1 and 2. Additional simulations were conducted for the period 1971-75. One set of simulations was based on the assumption that the federal subsidy program would continue at its 1970-1971 funding level. Simulations under this assumption were then run using different estimates for income and population for the period 1971-1975. These results are shown in Tables 3 and 4. Another set of simulations continued the earlier assumption of no federal subsidy program and a simulation was run under each of the income and population estimates; these results are shown in Tables 5 and 6.

Although the federal subsidies started in the mid-1960s, increases in the number of dental graduates as a result of these subsidies did not come

about for several years because of the time required for increases in dental school capacity to occur and the minimum time requirement of the dental profession to produce additional dentists. According to these simulations, the dentist-population ratio increased throughout this period; from .48 per thousand population in 1964 to .50 per thousand population in 1971 and to .52 per thousand population in 1975. However, even with increases in the dentist-population ratio, the price of dental care continued to rise (as did the number of visits per thousand population) because of continued increases in demand for dental care.

The simulations for the period 1965-1971 show that the effect of the federal subsidy on the dental sector was very slight. The price per visit is less than one percent lower in 1969 and 1970 while the number of visits are only slightly higher, approximately 0.1 percent, as a result of the federal subsidy. Expenditures on dental care are approximately two million dollars a year greater in 1969 and 1970 under the subsidy program.

The differences between the simulations with and without the subsidy become slightly more noticeable as one goes further into the future. By 1975 the dentist-population ratio is projected at .51 per 1,000 population with the subsidy versus .50 per 1,000 population without the subsidy, using the estimates of high income and high population (HY, HP); while it is projected at .52 per 1,000 population to .51 per 1,000 population, respectively under the lower population and income estimates (LY, LP). These dentist-population ratios, both with and without the subsidy, are projected to be greater than the dentist-population ratio that prevailed before the federal subsidy program started. Differences in price per visit are still small: $19.06 versus $18.99, respectively (HY, HP). Utilization and utilization

rates are approximately one percent higher by 1975 under the subsidy program.

B. An Alternative Subsidy Program to Increase the Supply of Dental Care.

As of 1971, the federal subsidy program to dental schools and students had already cost 310 million dollars; it was expected to continue at an annual cost of 58 million dollars. When the manpower subsidy was first requested by the dental profession, it was for 350 million dollars for a ten-year period to end in 1975. However, forthcoming legislation is likely to continue it for at least several more years. Assuming that a major objective of this program was to achieve an increase in the supply of dental care, one might ask whether an equivalent increase in supply could have been achieved, in an alternative manner, at lower cost.

One alternative to producing more dentists is a program to increase the productivity of existing dentists. For example, to encourage dentists to use auxiliaries, the entire cost to the dentist of additional auxiliaries could have been subsidized.

Tables 7-9 show the increase in dental productivity that would be required to provide the equivalent increase in visits as occurred under the subsidy program. According to these tables, dentists would have to be .06 percent more productive in 1970 and .9 percent in 1975 in order to produce as much dental care as would occur under the subsidy program.

The additional auxiliary personnel were then estimated if the dentists' productivity were to be sufficient to provide the same number of visits as provided under the subsidy program. This estimate of the additional auxiliaries was made using a production function estimated by Alex Maurizi.[8] The approximate cost of a federal subsidy (to pay the entire annual wages

1975 if past productivity increases in dental care had been incorporated into the estimate. In 1958 there were 1.7711 dental visits per person. Given the population estimates and likely supply of dentists used in the forecasts of dentist-population ratios that were made in 1962, the visit rate in 1975 would have been 1.8813 per person, if only a one percent increase in productivity were assumed to occur annually. The annual productivity increase from 1950-1971 was three percent; if this estimate had been incorporporated into the estimate, then the visit rate in 1975 would have been projected at 2.4277 visits per person. Thus, if the goal had been to maintain an equivalent supply of dental services per person rather than a dentist-population ratio, no federal program would have been required, if only one-third of the expected productivity increases were used in estimating the visit rate.

There are other difficulties with the use of a manpower-population ratio, in addition to not considering productivity increases, nor being able to specify policy alternatives other than increases in the numbers of dentists. If the demand for dental care increased, then what is the implication of maintaining the ratio of dentists to population? Even with increases in the dentist-population ratio the price of dental care has risen. For example, the dentist-population ratio went from .48 in 1964 to .50 in 1971, while the price of dental care, as measured by the Bureau of Labor Statistics, rose from 89.4 to 127.0 during that same period. Thus, if the intent underlying the maintenance of a dentist-population ratio were to insure that selected population groups would receive dental care, then increased dental prices could still occur, hence negating any such policy goal. A more appropriate policy indicator would be either the quantity of dental care actually received

of the additional auxiliaries) would be $965,000 per year in 1970; by 1975 the annual cost would be $21,000,000. Since the total federal subsidy for dentistry from 1965-1975 is estimated at 542 million dollars, the auxiliary subsidy program would, on a present value basis, be less than 10 percent of this amount.[9]

There are a number of assumptions involved in making a comparison of two such subsidy programs. Although illustrative, the results are so strikingly different in terms of their costs and in the timing of when the additional visits could occur under these two programs, that a policy of subsidizing an increase in the number of dentists to achieve an increase in the supply of dental services, should be examined more thoroughly before being undertaken, or, for that matter, continued.[10]

Perhaps the reason that alternative supply subsidy programs are not considered is that the very use of a dentist to population ratio technique for estimating shortages precludes the consideration of alternative policies.

III. The Use of Health Manpower-Population Ratios as a Basis for Public Policy.

When shortages are expressed in terms of gaps between current (or desired) manpower-population ratios and the likely future manpower ratio, then the only policy prescription is to increase the numbers of health manpower. If the health professions had expressed shortage in terms of the rate of output to population, e.g., dental visits to population, then policies other than increasing just one input to that output could be proposed and evaluated. In fact, had the dental profession had as its goal the maintenance of a visit to population rate rather than a dentist to population ratio, then without any federal subsidy program, the visit rate would have been maintained through

by these persons or their expected prices for dental care.

Increasing the number of dentists in the nation is an indirect way of insuring greater access to dental care for selected population groups. If there is really a redistributive objective underlying the use of a dentist-population ratio, then for selected population groups, it would be more appropriate to either increase their demand for dental care through the use of various payment mechanisms or to insure that an increase in the supply of dental care is directed specifically toward them. Merely increasing the number of dentists will not necessarily result in lower prices to them or that they will receive more dental care.

It is conceivable, however, that another reason for the widespread use of manpower to population ratios as a basis for policy is that the beneficiaries of these policies want to place the emphasis on numbers of dentists. Although twenty-two new dental schools were to have been constructed through 1971, only six new schools were constructed and most of the construction and institutional support went to the existing dental schools; further, the cost of adding first-year places to existing dental schools were greater ($177,462 of federal funds) than the cost of adding spaces by constructing new schools ($110,126 of federal funds). (The total cost per new space, including federal and matching funds were $381,089 and $173,045 respectively.) If the emphasis were not placed on increasing dentists as a means of achieving increases in the supply of dental care, or if increased supply of dental services were viewed as one alternative, along with increased demand, as a means of providing dental care to selected population groups, then it is unlikely that the existing dental schools would have been the beneficiaries of such large federal subsidies.

IV. Concluding Comments.

Large federal subsidies have been given to the health manpower sector. Legislation to continue these subsidies is up for renewal in 1974. In the forthcoming discussions on health manpower legislation, economists should undertake analyses on the goals and rationale underlying such subsidies, how well these subsidies have achieved their stated goals, how much funds and under what conditions should they be provided, and to whom should they be provided, the students or schools.

This paper attempts to answer some of these questions with respect to subsidies to the dental education sector. Through the use of an econometric model the impact of the federal subsidy on the dental sector was estimated. Simulations were conducted of the impact of greater numbers of dentists as a result of the federal program. These analyses were then compared to the results of simulations which assumed fewer numbers of dentists, which would have occurred had there not been a subsidy program. The effects of these simulations in terms of dental prices, visits, and expenditures were then used as the measures of impact that the subsidy program had. An alternative program, subsidizing the number of dental auxiliaries, was then compared to the subsidy program for increasing the number of dentists. It appeared that subsidizing an increase in the number of auxiliaries (by reimbursing dentists for the auxiliaries entire annual wage) could produce an equivalent increase in dental visits at less than one-tenth the cost of the dentist subsidy program.

The rationale for using dentist-population ratios as a basis for policy was then examined. If the goal is to achieve an increase in dental care to

selected population groups (or to the entire population), then dentist-population ratios are a poor indicator for policy. Users of such ratios have but one alternative to recommend--increases in the number of dentists.

Explicit redistributive policies regarding the quantity of dental care would enable these goals to be achieved by actions that can affect either the demand or supply side of the market. A greater number of alternatives can thus be considered and compared on the basis of their relative costs. Users of manpower to population ratios have no means by which to relate changes in these ratios to changes in the price or quantity of dental care received.

A possible reason for the continuing emphasis on health manpower ratios is that it is in the interest of the health education sector to define the debate over adequate health care in terms of shortages of highly skilled professionals, which only they can produce.

FOOTNOTES

1. Paul J. Feldstein, Financing Dental Care: An Economic Analysis, D.C. Health and Co., Lexington, Mass., 1973, Chapter 6.

2. Statement of Raymond J. Nagle, Dean, College of Dentistry, New York University, and Chairman, American Dental Association Council on Dental Education in U.S. Congress, House of Representatives, Hearings Before the Committee on Interstate and Foreign Commerce on H.R. 4999, H.R. 8774 and H.R. 8833, January 23, 1962. U.S. Government Printing Office, Washington, D.C., page 172.

3. Paul J. Feldstein, op. cit., page 88.

4. Ibid, page 106.

5. Ibid, page 120.

6. U.S. Congress, Senate, Report of the Committee on Labor and Public Welfare on S. 934, July 12, 1971, U.S. Government Printing Office, Washington, D.C., 1971, page 23.

7. Hearings, January 23, 1962, op. cit., page 182.

8. Maurizi's production function is:

   Ln VPD = 1.446 + .466 Ln AUX + 777 Ln HRD + .254 Ln CHR where VPD = annual patient visits per dentist, AUX = number of full-time auxiliaries employed per dentist, HRD = annual hours worked per dentist, and CHR = number of chairs in the dental office. The interpretation of this function is that a 10 percent increase in auxiliaries per dentist results in a 4.66 percent increase in visits per dentist (10 x .466). Thus, if we wish to calculate the increased auxiliary utilization necessary to produce a productivity increase (increase in VPD) of 0.06 percent in 1970 and 0.9 percent in 1975, the calculation would be as follows:

   1970: $$\frac{0.06 \text{ (percent increase in productivity)}}{.466 \text{ (coefficient of auxiliaries)}} = .13 \text{ percent}$$

   1975: $$\frac{0.9}{.466} = 1.93 \text{ percent}$$

   In 1970 there were approximately 1.4305 auxiliaries per dentist in the United States. A .13 percent increase would lead to an increase of 1.4324 auxiliaries per dentist (1.4305 x 1.0013). The increase in number of auxiliaries would be 193 (1.4324-1.4305 multiplied by the number of auxiliaries in 1970, 101,506). Since the average annual wage of auxiliaries in 1970 was $5,000, the additional costs of these 193 auxiliaries would be approximately $965,000 per year.

9. The educational sector for dental auxiliaries has been much more responsive to changes in its demand than the dental education sector. From 1961 to 1970, capacity of dental auxiliary schools and number of graduates expanded by 300-500 percent. During that same period dental school capacity and graduates expanded by approximately 7 percent.

10. It is of course possible that a different type of subsidy program might produce much larger increases in the number of dentists. However, it is doubtful that such subsidy programs would be acceptable to the health educational institutions. It might, therefore, be argued that the type of subsidies awarded are, in large part, those which are acceptable to the health education sector.

TABLE 1: A Simulation of the Health Professions Education Act, 1964-1971

	1964	1965	1966	1967	1968	1969	1970	1971
DDSY	$ 17,675	$ 19,278	$ 20,873	$ 22,531	$ 24,602	$ 26,445	$ 28,974	$ 31,629
(000's) TE	$3,088,079	$3,399,516	$3,736,867	$4,096,403	$4,543,015	$4,961,003	$5,522,519	$6,131,055
(000's) TV	296,077	310,091	322,520	335,357	350,099	363,901	380,765	398,439
VTH	1549.45	1602.87	1649.71	1699.09	1756.54	1807.70	1868.92	1935.75
PV	$ 10.43	$ 10.96	$ 11.57	$ 12.22	$ 12.98	$ 13.63	$ 14.50	$ 15.39
Y	$ 2,293	$ 2,441	$ 2,603	$ 2,768	$ 2,966	$ 3,138	$ 3,361	$ 3,591
DTH	.4846	.4858	.4881	.4910	.4938	.4967	.4986	.5020
POP	191,085	193,460	195,501	197,374	199,312	201,306	203,736	205,832
DDS	92,597	93,990	95,422	96,906	98,421	99,989	101,592	103,319
ΔD	+845	+1,393	+1,432	+1,484	+1,514	+1,568	+1,603	+1,728
R	2,368	1,852	1,880	1,908	1,938	1,968	2,000	2,032
DDS_{-1}	91,752	92,597	93,990	95,422	96,906	98,421	99,989	101,592
G	3,213	3,245	3,312	3,393	3,452	3,537	3,602	3,760
$P_{\Sigma 4}$	403	360	368	377	384	393	400	418
E_{-4}	3,616	3,605	3,680	3,770	3,836	3,930	4,003	4,117
E	3,836	3,930	4,003	4,177	4,292	4,410	4,554	4,686
S	3,836	3,930	4,003	4,177	4,292	4,410	4,554	4,686
S_{-1}	3,770	3,836	3,930	4,003	4,177	4,292	4,410	4,554
NS	66	94	73	174	115	118	144	132
(000's) MATCH	$ 0	$ 9,620	$ 7,499	$ 17,931	$ 11,785	$ 12,083	$ 14,821	$ 13,549
(000's) SUB	$ 0	$ 19,240	$ 14,997	$ 35,862	$ 23,570	$ 24,186	$ 29,642	$ 27,098
(000's) Other Dollars*	$ 0	$ 2,871	$ 7,599	$ 16,381	$ 19,850	$ 27,068	$ 28,645	$ 33,040
(000's) Total Dollars	$ 0	$ 31,731	$ 30,095	$ 70,173	$ 55,205	$ 63,337	$ 73,108	$ 74,087
(000's) Total Federal Subsidy Dollars	$ 0	$ 22,111	$ 22,597	$ 52,242	$ 43,420	$ 51,254	$ 58,287	$ 60,538

*Student plus Institutional Support

TABLE 2: A Simulation Without HPEA, 1964-1971

		1964	1965	1966	1967	1968	1969	1970	1971
	DDSY	$ 17,675	$ 19,278	$ 20,873	$ 22,531	$ 24,603	$ 26,451	$ 28,989	$ 31,675
(000's)	TE	$3,088,079	$3,399,516	$3,736,867	$4,096,403	$4,543,015	$4,960,350	$5,520,770	$6,125,651
(000's)	TV	296,077	310,091	322,520	335.557	350,099	363,803	380,525	397,757
	VTH	1549.45	1602.87	1649.71	1699.09	1756.54	1807.21	1867.74	1932.44
	PV	$ 10.43	$ 10.96	$ 11.57	$ 12.22	$ 12.98	$ 13.63	$ 14.51	$ 15.50
	Y	$ 2,293	$ 2,441	$ 2,603	$ 2,768	$ 2,966	$ 3,138	$ 3,361	$ 3,591
	DTH	.4846	.4859	.4881	.4910	.4938	.4965	.4982	.5008
	POP	191,085	193,469	195,501	197,374	199,312	201,306	203,736	205,832
	DDS	92,597	93,990	95,422	96,906	98,421	99,954	101,506	103,077
	ΔD	+845	+1,393	+1,432	+1,485	+1,514	+1,533	+1,552	+1,571
	R	2,368	1,852	1,880	1,908	1,938	1,968	1,999	2,030
	DDS_{-1}	91,752	92,597	93,990	95,422	96,906	98,421	99,954	101,506
	G	3,213	3,245	3,312	3,343	3,452	3,502	3,551	3,601
	$P_{\Sigma 4}$	403	360	368	377	384	389	395	400
	E_{-4}	3,616	3,605	3,680	3,770	3,836	3,891	3,946	4,001
	E	3,836	3,891	3,946	4,001	4,056	4,111	4,166	4,221
	S	3,836	3,891	3,946	4,001	4,056	4,111	4,166	4,221
	S_{-1}	3,770	3,836	3,891	3,946	4,001	4,056	4,111	4,166
	NS	66	55	55	55	55	55	55	55

TABLE 3: HPEA Simulation, 1972-1975: Low Income and Low Population Forecasts

	1972	1973	1974	1975
DDSY	$ 33,610	$ 35,648	$ 37,692	$ 39,771
(000's) TE	$6,629,644	$7,155,181	$7,704,025	$8,281,125
(000's) TV	413,474	428,929	444,771	461,049
VTH	1989.54	2044.31	2099.78	2156.45
PV	$16.03	$16.68	$17.32	$17.96
Y	$ 3,763	$ 3,936	$ 4,108	$ 4,281
DTH	.5058	.5099	.5143	.5191
POP	207,824	209,816	211,818	213,800
DDS	105,116	106,982	108,942	110,980
ΔD	+1797	+1867	+1959	+2039
R	2,066	2,102	2,140	2,179
DDS_{-1}	103,319	105,116	106,982	108,942
G	3,863	3,969	4,099	4,218
$P_{\Sigma 4}$	429	441	455	469
E_{-4}	4,292	4,410	4,554	4,686
E	4,823	4,959	5,095	5,232
S	4,823	4,959	5,095	5,232
S_{-1}	4,686	4,823	4,959	5,095
NS	137	136	136	137
(000's) MATCH	$ 14,000	$ 14,000	$ 14,000	$ 14,000
(000's) SUB	$ 28,000	$ 28,000	$ 28,000	$ 28,000
(000's) Other Dollars*	$ 30,000	$ 30,000	$ 30,000	$ 30,000
(000's) Total Dollars	$ 72,000	$ 72,000	$ 72,000	$ 72,000
(000's) Total Federal Subsidy	$ 58,000	$ 58,000	$ 58,000	$ 58,000

*Student plus Institutional Support

TABLE 4: HPEA Simulation, 1972-1975: High Income and High Population Forecasts

		1972	1973	1974	1975
	DDSY	$ 34,460	$ 37,380	$ 40,380	$ 43,445
(000's)	TE	$6,796,025	$7,502,819	$8,253,425	$9,045,994
(000's)	TV	417,097	436,301	456,116	476,450
	VTH	1996.88	2058.84	2121.88	2185.55
	PV	$ 16.29	$ 17.20	$ 18.10	$ 18.99
	Y	$ 3,821	$ 4,051	$ 4,281	$ 4,513
	DTH	.5033	.5048	.5068	.5091
	POP	208,874	211,916	214,958	218,000
	DDS	105,116	106,982	108,942	110,980
	ΔD	+1,797	+1,867	+1,959	+2,039
	R	2,066	2,102	2,140	2,179
	DDS_{-1}	103,319	105,116	106,982	108,942
	G	3,863	3,969	4,099	4,218
	$P_{\Sigma 4}$	429	441	455	469
	E_{-4}	4,292	4,410	4,554	4,686
	E	4,823	4,959	5,095	5,232
	S	4,823	4,959	5,095	5,232
	S_{-1}	4,686	4,823	4,959	5,095
	NS	137	136	136	137
(000's)	MATCH	$ 14,000	$ 14,000	$ 14,000	$ 14,000
(000's)	SUB	$ 28,000	$ 28,000	$ 28,000	$ 28,000
(000's)	Other Dollars*	$ 30,000	$ 30,000	$ 30,000	$ 30,000
(000's)	Total Dollars	$ 72,000	$ 72,000	$ 72,000	$ 72,000
(000's)	Total Federal Subsidy Dollars	$ 58,000	$ 58,000	$ 58,000	$ 58,000

*Student plus Institutional Support

TABLE 5: Simulation, 1972-1975 without HPEA; Low Income and Low Population Forecasts

		1972	1973	1974	1975
	DDSY	$ 33,707	$ 35,798	$ 37,923	$ 40,104
(000's)	TE	$6,619,038	$7,137,500	$7,676,769	$8,241,706
(000's)	TV	412,207	426,931	441,829	456,987
	VTH	1983.44	2034.79	2085.89	2137.45
	PV	$ 16.06	$ 16.72	$ 17.37	$ 18.03
	Y	$ 3,763	$ 3,936	$ 4,108	$ 4,281
	DTH	.5036	.5065	.5094	.5123
	POP	207,824	209,816	211,818	213,800
	DDS	104,666	106,272	107,896	109,537
	ΔD	+1,589	+1,607	+1,624	+1,641
	R	2,062	2,093	2,125	2,158
	DDS_{-1}	103,077	104,666	106,272	107,896
	G	3,650	3,700	3,749	3,799
	$P_{\Sigma 4}$	406	411	417	422
	E_{-4}	4,056	4,111	4,166	4,221
	E	4,276	4,331	4,386	4,441
	S	4,276	4,331	4,386	4,441
	S_{-1}	4,221	4,276	4,331	4,386
	NS	55	55	55	55

TABLE 6: Simulation, 1972-1975 without HPEA; High Income and High Population Forecasts

		1972	1973	1974	1975
	DDSY	$ 34,553	$ 37,537	$ 40,627	$ 43,807
(000's)	TE	$ 6,785,125	$ 7,484,269	$ 8,224,144	$ 9,002,869
(000's)	TV	415,830	434,303	453,174	472,389
	VTH	1990.82	2049.41	2108.20	2166.92
	PV	$ 16.32	$ 17.23	$ 18.15	$ 19.06
	Y	$ 3,821	$ 4,051	$ 4,281	$ 4,510
	DTH	.5011	.5015	.5019	.5025
	POP	208,874	211,916	214,958	218,000
	DDS	104,666	106,272	107,896	109,537
	ΔD	+1,589	+1,607	+1,624	+1,641
	R	2,062	2,093	2,125	2,158
	DDS_{-1}	103,077	104,666	106,272	107,896
	G	3,650	3,700	3,749	3,799
	$P_{\Sigma 4}$	406	411	417	422
	E_{-4}	4,056	4,111	4,166	4,221
	E	4,276	4,331	4,386	4,441
	S	4,276	4,331	4,386	4,441
	S_{-1}	4,221	4,276	4,331	4,386
	NS	55	55	55	55

TABLE 7: Productivity Increases Needed in Non-HPEA Situation to Provide Number of Visits Equivalent to HPEA Situation

	1964	1965	1966	1967	1968	1969	1970	1971
(000's) Total Visits With HPEA	296,007	310,091	322,520	335,357	350,099	363,901	380,765	398,439
(000's) Total Visits Without HPEA	296,077	310,091	322,520	335,357	350,099	363,803	380,525	397,757
DDS* Without HPEA	92,597	93,990	95,422	96,906	98,421	99,954	101,506	103,077
VPD** Without HPEA	3197.48	3299.19	3379.93	3460.64	3557.16	3639.70	3748.79	3858.83
VPD without HPEA necessary to Equal TV with HPEA	3197.48	3299.19	3379.93	3460.64	3557.16	3640.68	3751.16	3865.45
Percent increase in productivity necessary without HPEA	00.00	00.00	00.00	00.00	00.00	00.03	00.06	00.17

*Number (stock) of dentists;

**Annual patient visits per dentists.

TABLE 8, 9: Productivity Increases Needed in Non-HPEA Situation to Provide Number of Visits Equivalent to HPEA Situation, 1972-1975

	1972	1973	1974	1975
a, Low Income and Low Population Forecasts				
(000's) Total Visits with HPEA	413,474	428,929	444,771	461,049
(000's) Total Visits without HPEA	412,207	426,931	441,829	456,987
DDS* Without HPEA	104,666	106,272	107,896	109,537
VPD** Without HPEA	3938.31	4017.34	4094.95	4171.99
VPD without HPEA necessary to equal TV with HPEA	3950.41	4036.14	4122.22	4209.07
Percent Increase in productivity necessary without HPEA	00.31	00.47	00.67	00.89
b. High Income and High Population Forecasts				
Total Visits with HPEA	417,097	436,301	456,116	476,450
Total Visits without HPEA	415,830	434,303	453,174	472,389
DDS without HPEA	104,666	106,272	107,896	109,537
VPD without HPEA	3972.92	4086.71	4200.10	4312.60
VPD without HPEA necessary to equal TV with HPEA	3985.03	4105.51	4227.37	4349.67
Percent Increase in productivity necessary without HPEA	00.30	00.46	00.65	00.86

*Number (stock) of dentists.

**Annual patient visits per dentists.

APPENDIX A: A Description of an Econometric Model of the Dental Sector.

The primary source for much of the data was American Dental Association publications. Data on price of dental visits,* number of patient visits, and dentist incomes (net and gross) came from the Surveys of Dental Practice, published by A.D.A.'s Bureau of Economic Research and Statistics in 1955, 1959, 1962, 1965, 1968, and 1971 (data in each is for the previous year, i.e., 1954, 1958, 1961, 1964, 1967, and 1970.) Data on the stock of dentists came from the A.D.A.'s The Distribution of Dentists in the United States by State, Region, District, and County. This publication has been issued fairly regularly on an annual basis; it was not published for 1967 so straight-line interpolation was used to derive figures for that year.

Demographic data on population, personal income, and mortality rates came from standard U.S. Government sources. These included The Statistical Abstract of the United States (various editions), Current Populations Reports (Series P-25, Nos. 304, 348, 414), and Survey of Current Business (April 1969, August 1969). Data on dental school spaces, enrollments, dropout rates, and graduates came from various Department of Health, Education and Welfare publications.** Finally, data on school construction costs and federal and non-federal construction funding was derived from data published on the Health Professions Educational Assistance program. See

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*This "average price per dental visit" was calculated as

$$PV = \frac{\text{mean annual gross income of dentists}}{\text{mean annual patient visits per dentists}}$$

**Of particular importance was U.S. Department of Health, Education and Welfare, Bureau of Health Manpower Education, Division of Dental Health, Manpower Supply and Educational Statistics for Dentists and Dental Auxiliaries (As of March 3, 1971) P.H.S. Publication No. 263, Section 20, 1971.

especially U.S. Congress, Senate, Committee on Labor and Public Welfare, Health Professions Educational Assistance Amendments of 1971: Report on S. 934; 92nd Congress, First Session, Senate Report No. 92-251, July 12, 1971; Washington, D.C., Government Printing Office, 1971.

The observation used in the statistical analyses consisted of the seven regions (as defined by the A.D.A.) of the United States for each of the six years in which a Survey of Dental Practice was conducted (1955, 1958, 1961, 1964, 1969, 1970). Data for those years not available in the A.D.A. publications was obtained from the various government publications listed above, when necessary. There were thus seven observations from each of six years, giving a total of forty-two observations.

The following are the equations for the dental econometric model.

1. Education and Manpower Markets.

As discussed above, the number of dental school spaces is the constraint on dental school enrollments. Thus first-year enrollments were set equal to first-year spaces in schools. The number of these spaces is equal to the existing spaces plus newly-constructed spaces. New spaces are a function of construction subsidy funds (federal and non-federal), divided by $308,000 which was the average total cost per dental space built under the Health Professions Education Assistance Act (HPEA) between 1965-1971.

$$(1) \quad NS = \frac{SUB + MATCH}{\$308,000}$$

$$(2) \quad S = S_{-1} + NS$$

$$(3) \quad E = S$$

Dental school graduates are equal to first-year entrants four years

earlier, less those who have withdrawn from school. "Dropouts" are set at 10 percent of an entering first-year class (this was approximately the national average between 1964-1970).

(4) $P_{\Sigma 4} = .10\ E_{-4}$

(5) $G = E_{-4} - P_{\Sigma 4}$

The supply of active dentists is defined as the existing stock, plus (minus) additions (deletions) to that stock. Additions (deletions) are the total of new graduates minus dying or retiring dentists. Annual deaths and retirements are estimated at two percent of the previous year's stock. Finally, the current year dentist:population ratio is calculated on a per thousand population basis.

(6) $R = .02DDS$

(7) $\Delta DDS = G - R$

(8) $DDS = DDS + \Delta DDS$

(9) $DTH = DDS/POP$

2. The Market for Dental Visits.

The demand and supply equations for dental visits were estimated using two stage least squares. They are:

(10a) $VTH_D = 1106.27 + 1.26Y - 246.59\ PV$

(t-statistic) (11.24) (-8.98)

(11a) $VTH_S = -457.59 + 3412.65\ DTH + 35.28\ PV$

(t-statistics) (17.71) (4.60)

In logarithms, these equations are:

(10b) $\text{Log } VTH_D = -1.398 + 1.78 \log Y - 1.41 \log PV$

(t-statistic) (14.14) (-10.60)

(11b) Log VTH_S = 3.314 + 1.05 log DTH + 0.21 log PV

(t-statistic) (20.01) (4.38)

These results, which are highly significant (shown by high t-statistics) have the expected signs. Demand for dental care, as anticipated, varies directly with income and inversely with price; the supply of dental care varies directly with both the stock of dentists and the price per visit.

Studying the logarithmic forms, one observes that the demand for visits is both price and income elastic (|elasticity|>1), while the supply of visits is inelastic (|elasticity|<1) with respect to price and elastic with respect to the supply of dentists.

The "reduced form" equations (simultaneous solution of 10a and 11a for VTH and PV), which give the equilibrium values for price and utilization, are as follows:

(12a) PV = 5.55 + .0045 Y - 12.11 DTH

(13a) VTH = -261.65 + .16Y + 2985.51 DTH

In logarithms, the reduced forms are (simultaneous solution of 10b and 11b):

(12b) Log PV = -2.909 + 1.10 log Y - 0.65 log DTH

(13b) Log VTH = 2.704 + 0.23 log Y + 0.91 log DTH

These "reduced forms" show the effect of per capita income and the stock of dentists on the market price and utilization of dental care. The price of care varies directly with consumer income and inversely with the dentist supply; the visit rate varies directly with both income and the dentist supply.

Finally, equations for aggregate outcomes are specified. Total visits are the product of the visit rate (per 1,000 population) and the population (in thousands):

(14) $TV = VTH \cdot POP$

Total expenditures for care are determined by the total number of visits times the average price per visit:

(15) $TE = TV \cdot PV$

The mean net income of dentists is calculated as total expenditures divided by the number of dentists (this represents average gross income) times .519 (mean net income of dentists was 51.9 percent of their gross income, according to the 1971 Survey of Dental Practice):

(16) $DDSY = (TE/DDS) \cdot .519$

Due to data problems, we were unable to estimate a production function for dental services. However, in several illustrative analyses, we have employed a production function estimated by Alex Maurizi (see "Production Function for the Dental Service Industry," Economic Essays on the Dental Profession, the University of Iowa, Iowa City, Iowa, 1967, p. 58). Apparently, Maurizi was allowed by the A.D.A. to examine the actual survey replies for that year, thus enabling him to make a cross-section estimation of a production function. Maurizi's production function is:

(17) $LnVPD = 1.446 + .466\ LnAUX + .777\ LnHRD + .254\ Ln\ CHR$

(t-statistic) (18.8) (22.7) (10.8)

$R^2 = .31$

1. List of Equations for the Dental Econometric Model

(1) $NS = \frac{Sub + Match}{\$308,000}$

(2) $S = S_{-1} + NS$

(3) $E = S$

(4) $P_{\Sigma 4} = .10E_{-4}$

(5) $G = E_{-4} - P_{\Sigma 4}$

(6) $R = .02\ DDS_{-1}$

(7) $\Delta DDS = G - R$

(8) $DDS = DDS_{-1} + \Delta DDS$

(9) $DTH = \frac{DDS}{POP}$

(10a) $VTH_D = 1106.29 + 1.26\ Y - 246.59\ Log\ PV$

(10b) $Log\ VTH_D = -1.398 + 1.78\ Log\ Y - 1.41\ Log\ PV$

(11a) $VTH_S = -457.59 + 3412.65\ DTH + 35.28\ PV$

(11b) $Log\ VTH_S = 3.314 + 1.05\ Log\ DTH + 0.21\ Log\ PV$

(12a) $PV = 5.55 + .0045Y - 12.11\ DTH$

(12b) $Log\ PV = -2.909 + 1.10\ Log\ Y - .65\ Log\ DTH$

(13a) $VTH = -261.85 + .16\ Y - 2985.51\ DTH$

(13b) $Log\ VTH = 2.704 + .23\ Log\ Y + .91\ Log\ DTH$

(14) $TV = VTH \cdot POP$

(15) $TE = TV \cdot PV$

(16) $DDSY = (TE/DDS) \cdot (0.519)$

(17) $LnVPD = 1.446 + .466\ LnAUX + .777\ LnHRD + .254\ LnCHR$

2. Key to Symbols for Variables

SUB = construction subsidy funds (federal funds)

MATCH = matching construction funds (non-federal funds)

NS = additions to dental school spaces (first year)

S = dental school spaces

E = first-year dental school students

G = dental school graduates

P = dental school dropouts

R = dentists retiring or dying

ΔDDS = change in the number of dentists

DDS = number (stock) of dentists

POP = civilian population in thousands

DTH = active dentists per thousand population

Y = per capita personal income

PV = price per dental visit

VTH = visits per thousand population

VTH_D = visits demanded per thousand population

VTH_S = visits supplied per thousand population

TV = total dental visits

TE = total expenditures for dental care

DDSY = mean net income of dentists

VPD = annual patient visits per dentists

AUX = number of full-time auxiliaries employed per dentist

CHR = number of chairs in the office

X_{-n} = value of variable $\underline{X}$ n years ago

$X_{\Sigma n}$ = sum of variable $\underline{X}$ over past n years